ARTHROPOD POPULATIONS OF THE VEGETATION OF WHEATLAND AND NATIVE GRASSLAND AT SASKATOON, SASKATCHEWAN

BY
ARNI PALL ARNASON
B.S., University of Saskatchewan, 1929
M.S., University of Saskatchewan, 1931

AN ABSTRACT OF A THESIS
SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN
ENTOMOLOGY IN THE GRADUATE SCHOOL OF
THE UNIVERSITY OF ILLINOIS, 1941

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Introduction

The arthropod faunas of two fields, a native grassland and a field planted to wheat every year, are compared qualitatively and quantitatively by means of population data secured by sweeping the vegetation with an insect net. The ten-year period, 1931-1940, was selected as a time unit to show population trends and weather effects over a period of years. The conditions in a field in which the same crop is cultivated continuously provide the nearest approach to the continuity of vegetation which exists in native grassland. This study is a part of the investigations carried on by the Dominion Entomological Laboratory at Saskatoon, Saskatchewan, under the direction of K. M. King, officer in charge, and has been maintained throughout the period, 1923 to 1940. The project included quantitative sampling of soil and vegetation in a total of twelve cultivated and native fields, representing the chief types of crop rotation and native communities of the region. The writer has been associated with the work since 1927 and has been in full charge of field and laboratory work in this study since 1934.

Methods

Population is estimated on the basis of the number of animals secured by a definite number of sweeps with an insect net. The method used in this study was developed and standardized by K. M. King, and differs from those used by other investigators in three important respects. Sweepings are made under as nearly similar weather conditions as seasonal variations permit, and not at regular intervals without regard for weather. The sweepings are made at equivalent phenological periods. The method of sweeping has been designed

to eliminate errors from disturbance by the sweeper and to minimize the personal factor.

A standard American insect net with a frame 14 inches in diameter and a bag of closely woven cloth is used. One net and one pint cyanide jar with spring-top are provided for each field to be sampled. A pocket thermometer, black and white bulb thermometers and a psychrometer are carried to measure prysical factors operating at the time of sampling.

The first series of samples is taken on the first spring day on which insect activity is noted. The series of later samplings are spaced at intervals of approximately two weeks and the last samples are taken early in October, or as near the end of insect activity as one can be sure of suitable weather. Ideal conditions are clear, calm weather, which, in the spring and fall, is warm for the season. On a day of intermittent sunshine, sweeps are made only when the sun is shining. Sweeps are never made if a strong wind is blowing. Twelve sets, or "series" are taken each year. During the cooler parts of the active season the series are spaced farther apart than during the season of peak activity. In each series, samples were taken in all fields under study at approximately the same time on the same day, between 11 A. M. and 2 P. M. The sweeps in the two situations discussed here usually were taken within a period of half an hour.

The number of sweeps was selected according to the number of animals present. In all cases, except by error, this number was a factor of 100. In spring and fall when few insects were present, 25 or 50 sweeps were made in each field. In summer, only five or ten sweeps were taken. At this period, populations are often so large that it may take several days to separate and count the specimens from five sweeps.

The sweep is taken with fair, even speed through the vegetation. In low vegetation or bare soil, the net is kept as low as possible. In tall vegetation the sweep is directed diagonally downward to sample all heights. The length of the horizontal sweep remains at all times at five feet; the sweeps are made from right to left. At the end of each stroke, the net is brought back to its original position in such a manner that the

net bag closes over the net ring and no insects can escape. Two to several paces forward are taken between each stroke so that every sweep is made in an area no more disturbed by the operator than for the first one. The direction, when sweeping, is into the sun and breeze whenever possible. The area swept is more or less centrally located in the field to avoid marginal effects. When the number of sweeps has been completed, the net is swung back and forth rapidly to shake the insects down into the bag and the end of the closed net is then pushed into a labelled cyanide bottle, making sure that all the insects are within the bottle, and the jar top clamped on. Complete physical data and field notes on stage of vegetation are taken.

In the laboratory, the insects are separated from other material collected in sampling and sorted into suitable storage containers. Thoroughness in examining the material cannot be too greatly emphasized. Material collected and the net bag, should be re-examined again and again under magnification to be sure of finding all the minute specimens. Adult insects are stored dry in tins. Large soft-bodied insects are placed in alcohol or separate containers. All immature insects and other arthropods are put in vials containing 70% alcohol. Very minute specimens are collected separately from larger insects. These are all placed together fully labelled ,until they can be identified and recorded. Every animal is recorded. The numerical record of each species or other category as far as it is possible to be determined, is kept by years and fields, the samples within a year in chronological order. The record shows the sample number, the date of sampling, the number of sweeps taken, the number, developmental stage and deposition of every species. The records are listed in the taxonomic order used in Comstock's "Introduction to Entomology." All animals are permanently retained. When all specimens are kept, as knowledge of the local fauna improves, corrections in original listings can be made by re-examination of the specimens.

In order to evaluate a tremendous mass of data, tables summarizing the data from the two fields were prepared. Some

237 tables were prepared to form the basis for further analysis. For each species or species group, in each field, the numbers actually taken in a given number of sweeps were expanded into the number that presumably would have been present, had one hundred sweeps been taken. The data were arranged in columns by years, and a column for the ten-year average. In each column the data for each of the twelve samples taken in the year were tabulated in order, and the yearly totals added at the bottom. In some cases, the immature stages were also tabulated separately from the adults and shown on the same table. These tables show at a glance population fluctuations, seasonal distribution and many other significant facts.

Climate and Ecology

The two habitats studied are in the general region known as aspen parkland at the northern margin of the Great Plains of North America. The climate is typically continental and is characterized by frequent and large fluctuations in temperature and very variable precipitation. The mean annual temperature is 33.3°F; the lowest winter temperature is about -55°F, the highest summer one, 104°F. The mean annual rainfall is 13 inches. In general, the weather is dry and sunny, except for the few days in the year when precipitation occurs. Most of the moisture falls during the summer. The days are very long in the summer, bright and hot during the day and cold at night. Winter days are correspondingly short and nights long, but the days are sunny. Snow usually does not melt during the short winter days, but stays on the ground and accumulates for months.

The weather for the particular ten-year period involved in this study was, in general, above normal in temperature and below normal in precipitation. The outstanding phenomena are, briefly, as follows: 1933 was extremely hot during the mid-summer period. 1934 had an early, unusually warm spring and continued the drought conditions begun in 1933. 1935 was the coldest summer and the wettest year in the ten-year period. 1936 had a mid-summer drought. 1937

was a year of severe heat and drought. 1938 was a wet year. 1939 had an unusual amount of rainfall in June but otherwise was subnormal in rainfall.

For a detailed account of the animal ecology of a typical aspen parkland, the reader referred to the study made by Bird at Birtle, Manitoba, published in 1930. The grassland field studied was in a relatively large piece of undisturbed prairie near the University of Saskatchewan. No aspen groves nor clumps of native shrubs are located on the grassland area selected. The dominants are the grasses: *Agropyron smithii* Rydb., *Agropyron pauciflorum* Hitchc., *Agropyron dasystachyum* (Hook) Scribn., *Stipa comata* Trin. and Rup., *Poa cusickii* Vasey, *Koeleria gracilis* Pers. and *Bouteloua gracilis* (H.B.K.) Lag. The sedge, *Carex Eleocharis* Bailey and the sages, *Artemisia frigida* Willd. and *Artemisia graphalodes* (Nutt.) Rybd. are abundant and important. Many flowering plants, such as the prairie crocus, wild rose, campanula, vetches, gaillardia, goldenrods and asters give color to the spring and summer aspect of the prairie. In addition, patches of the prairie clubmoss, *Selaginella densa* Rydb. occur.

The wheatland used in this study was a three-acre field on the University farm, part of a much larger field which was originally handled as one unit, but has since been used for several types of rotations. The field in this study has been planted to wheat every year since 1928. The wheat is the main vegetation of the field, except for weeds. In the spring, a growth of small weed seedlings is destroyed by the first tillage. Wheat begins to grow about mid-May or early June. After the grain has matured and been cut, in August, weeds again grow up in the stubble. The chief weeds are: lamb's quarter, goosefoot, red-root pigweed, wild rose and several mustards. From 1936 on, Russian thistle occurred in great numbers in the field, and has been the dominant weed since that time. The weed composition of the flora is important because many of the insects present feed on the weeds and not on the wheat.

Qualitative Comparison of the Fauna of Grassland and Wheatland Vegetation

Since grassland vegetation is less subject to variation in composition from year to year than wheatland with its attendant weeds, and since it includes a greater variety of plants than the wheatland, a greater number of species is present. Since wheat and native grasses belong to the same family, it is also to be expected that a great many species are common to both situations. Few insects known to feed primarily on grasses were found abundantly in the wheat, but species which occur in small numbers on broad-leaved grassland plants frequently multiply to great abundance on the concentrations of weeds in the wheat. A few insects which feed on wheat were not found in the prairie.

No complete species list has been attempted because too many species could not be named. The following lists are intended to summarize the most important insects, or groups of insects, by habitat.

Important Species in Both Grassland and Wheatland

Orthoptera:	
Acrididae:	*Camnula pellucida* Scud.
Thysanoptera:	*Aeolothrips fasciatus* L. (predator)
	Anaphothrips obscurus (Muller) (?)
	Undetermined species No. 1
Neuroptera:	*Chrysopa oculata* Say (predator)
Hemiptera:	
Lygaeidae:	*Nysius ericae* (Schill.)
	Geocoris bullatus (Say) (predator)
Miridae:	*Trigonotylus ruficornis* (Geoff.)
	Lygus elisus VanD.
Nabidae:	*Nabis ferus* L. (predator)
Anthocoridae:	*Triphleps insidiosus* Say (predator)
Piesmidae:	*Piesma cinerea* (Say)
Homoptera:	
Cicadellidae:	*Deltocephalus signatifrons* VanD.
	Acertagallia sanguinolenta (Prov.)

	Eugnathodus abdominalis (VanD.)
Aphidae:	Many species
Fulgoridae:	*Liburnia* spp.
Coleoptera:	
Chrysomelidae:	*Phyllotreta pusilla* Horn
Lepidoptera:	
Gelechiidae:	Many species
Diptera:	
Tipulidae:	*Helobia hybrida* Meig.
Chironomidae:	Many species.
Sciaridae:	Some species
Dolichopodidae:	*Medeterus nigripes* Lw.
Agromyzidae:	*Phytomyza acuticornis* Lw.
	Agromyza coquilletti Mall.
Chloropidae:	*Madiza* parva (Adams)
Muscidae:	*Hylemyia* spp.
Sarcophagidae:	Many species (parasites)
Tachinidae:	Many species (parasites)
Hymenoptera:	
Ichneumonoidea:	Many species (parasites)
Proctotrupoidea:	Many species (parasites)
Chalcidoidea:	Many species (parasites)
Apoidea:	Andrenidae: *Halictus* spp.

Species Abundant or Characteristic in Grassland Only

Collembola:	*Sminthurus* sp.
Orthoptera:	
Acrididae:	*Melanoplus infantilis* Scud.
	Melanoplus dawsoni (Scud.)
	Aeropedellus clavatus (Thom.)
	Psoloessa delicatula delicatula (Scud.)
Neuroptera:	
Coniopterygidae:	*Malacomyza fitchi* (Banks) (predator)
Hemiptera:	
Coreidae:	*Corizus crassicornis* L.
Lygaeidae:	*Geocoris discopterus* Stal. (predator)

Miridae:	*Chlamydatus bakeri* Bergr.
	Labops hesperius Uhl.
Reduviidae:	*Sinea diadema* Fab. (predator)
Homoptera:	
Cicadellidae:	*Deltocephalus auratus* G. & B. or near
	Deltocephalus cruciatus O. and B.
	Deltacephalus collinus Boh.
	Deltocephalus misellus Ball
	Deltocephalus ordinatus Ball
	Aconura, probably *acuticauda* (B.)
Fulgoridae:	*Laccocera vittipennis* VanD.
	Bruchomorpha dorsata Fitch
	Scolops angustatus Uhl.
Psyllidae:	*Aphalara* sp.
Aphidae:	*Iziphya flabella* (Sanb.)
Coleoptera:	
Coccinellidae:	*Hippodamia parenthesis* (Say) (predator)
	Coccinella transversoguttata Fald. (predator)
Phalacridae:	*Phalacrus* sp.
Chrysomelidae:	Many species
Curculionidae:	*Tychius* sp.
	Hyperodes ulkei (Dietz)
Lepidoptera:	
Gelechiidae:	Undetermined species, on *Artemisia frigida*
Elachistidae:	*Elachista* n.sp. (?)
Geometridae:	Larvae
Diputera:	
Cecidomyidae:	Many species
Scatopsidae:	*Reichertella femoralis* Meig.
Chloropidae:	*Chlorops rubicunda* Adams
	Meromyza americana Fitch
	Diplotoxa near *pulchripes* Lw.
	Diplotoxa versicolor Lw.
	Madiza neglecta Becker
	Madiza near *triangulata* Becker

	Oscinella incerta Becker
Muscidae:	*Limosia cilicauda* Mall.
Hymenoptera:	
Tenthredinidae:	One or two species
Cynipoidea:	Many species (parasites and gall-formers)
Formicidae:	*Myrmica scabrinodis* Nyl.

SPECIES ABUNDANT OR CHARACTERISTIC IN WHEATLAND ONLY

Orthoptera:	
Acrididae:	*Melanoplus femur-rubrum* DeGeer
	Melanoplus mexicanus Saus.
	Melanoplus packardii Scud.
Hemiptera:	*Melanoplus bivittatus* (Say)
Miridae:	*Melanotrichus coagulatus* (Uhler)
Homoptera:	
Cicatdellidae:	*Deltocephalus striatus* (L.)
	Macrosteles divisus Uhler
Homoptera:	
Aphidae:	*Aphid* on *Chenopodium*
	Macrosiphum granarium Kby. (?)
Coleoptera:	
Chrysomelidae:	*Psylliodes punctulata* Melsh.
Curculionidae:	*Ceutorhynchus* sp.
Lepidoptera:	
Pyralidae:	*Loxoxtege sticticalis* L.
Gelechiidae:	Unidentified species, on *Chenopodium*
Diptera:	
Empidae:	*Platypalpus aequalis* Lw. (predator as larva)
Chloropidae:	*Chloropisca glabra* Meig. (predator as larva)
Muscidae:	*Hylemyia cilicrura* Rond.
Hymenoptera:	
Cephidae:	*Cephus cinctus* Nort.

DISCUSSION OF ABUNDANCE, LIFE HISTORY AND ECOLOGICAL RELATIONSHIPS OF THE FAUNA

PHYLUM ARTHROPODA. Almost the entire population of arthropods taken was insects. Spiders were a small but constant component of the fauna. Phalangids were taken on one occasion and one pseudoscorpion on another, in the wheatfield. These also occur rarely in the grassland, but were not collected. Mites were sometimes abundant in grassland but were unimportant in wheat.

The average number of arthropods per 100 sweeps, considering the entire ten-year period, is about 6000 in grassland and 850 in wheatland. The number of individuals present in any one collection varied from ten to over 62,000 in grassland and from none to 22,000 in wheatland.

The curve of average abundance (Plate I) throughout the season shows the following trend: In grassland, about 100 arthropods are present per 100 sweeps in April. Numbers increase so rapidly in May that by the first of June about 4000 individuals are present. Peak abundance of 18,000 per 100 sweeps is reached in late July. Thereafter numbers begin to decrease, rapidly in August, then more gradually until the end of the season. The late fall population is about seven times that of early spring. In wheatland, the trend is similar to that of grassland but populations are much smaller and the numbers do not become large until the middle of summer. The average number in April is about 11 per 100 sweeps. This has increased only nine-fold by mid-June but in grass the increase is 60-fold by this time. After mid-June, however, total arthropod numbers increase rapidly in wheat, reaching a peak in late July of 2000. With harvest, the first week in August, wheat populations decrease suddenly, and drop to a tenth of the peak. From then on, numbers diminish gradually as in grassland. The late fall populations in wheat decline much more than those in grassland because ripening of weeds and fall tillage have forced the insects out of the field or into the soil.

The effects of climatic factors on population as a whole

are strikingly demonstrated by the results of extreme drought and moisture conditions. Populations were very greatly reduced by the severe drought of 1936-'37 and were reduced almost as much by the lesser drought of 1933. The very wet season of 1935 resulted in the highest populations of the ten-year period. Populations in both fields responded to these conditions, but not all insects alike. For example, in periods of drought, grasshoppers increase, but aphids decrease.

ARANEIDA. Spiders are present every year at all times on grassland vegetation but are not taken by sweeping in wheat fields in the spring and fall because the ground is bare. Spider populations averaged 38 in grassland and 14 in wheatland per 100 sweeps. Spiders do not increase in numbers during the summer to such proportionately high populations as do insects. Two periods when spiders hatch, the first in early May and the second in early July, produce rapid increases; but populations remain stable after the new level of abundance is established.

ACARINA. Mites have been present in grassland commonly, and in mid-summer average 150 per 100 sweeps. Most of these are saprophytic in habit. In the wheat field, mites occur rarely in small numbers, averaging only 1.3 per 100 sweeps. Of these, one-fifth were found on insects.

COLLEMBOLA. A species of *Sminthurus,* which is well adapted to the dry grassland environment, comprises one-fourth of the grassland insects. In wheat, it was negligible, except in one year, 1940, when it became very abundant. *Sminthurus* appears in grassland in early June and sometimes builds up enormous populations which become as high as 33,000 per 100 sweeps. After the peak in July, numbers decrease rapidly and, by the end of August, few *Sminthurus* remain. *Sminthurus* was observed to feed on *Stipa* and *Agropyron* in the prairie and Russian thistle in the wheat. Abundance does not seem to be closely correlated with weather conditions. It was most abundant in years of subnormal rainfall. In the very wet season of 1935, *Sminthurus* was abundant but not as numerous as in some of the drier years.

ORTHOPTERA. The family Acrididae, represented by a

number of species in both fields, and the family Oecanthidae, by one specimen, *Oecanthus nigricornis quadripunctatus* Beut., were the only Orthoptera taken. Grasshoppers are important and characteristic insects of grassland and several species are economically important in grain fields. Grasshoppers are not satisfactorily sampled by sweeping vegetation, because of their great activity, but the trends revealed by the data correspond with the history of grasshopper outbreaks in the district.

Acrididae form .4% of the grassland insects, averaging 25 per 100 sweeps, and 1.7% of the wheat insects, averaging 14 per 100 sweeps. Although there were smaller numbers of grasshoppers in the wheat than in prairie, they were more destructive because the species were more voracious feeders and because the young wheat plant rarely recovers from an attack and, in the prairie, the plants are perennials which recover from severe defoliation. The ten-year period was one of unusual abundance of grasshoppers, with outbreaks of economic importance in every year since 1933 in the Saskatoon district. July of 1933 was hot and dry and an enormous increase in grasshoppers occurred, becoming a peak in 1934. A second peak occurred in 1938-39 and populations dropped to uneconomic proportions in 1940.

Melanoplus mexicanus mexicanus Saus. and *Camnula pellucida* Scud. are by far the most numerous and destructive grasshoppers of the wheatfield. In grassland, the only abundant species is *Melanoplus infantilis DeGeer*. *M.packardii* Scud. is abundant when *M. mexicanus* is abundant but in a lesser degree. Although the grassland study field represents anly one type of grassland community, the data bear out the well known fact that major outbreaks of *Melanoplus* do not originate in the native grass associations but develop in the cultivated fields. *M. femur-rubrum* DeGeer is of no importance, never taken in the grassland and unimportant in wheat. *Camnula pellucida* is consistently present in both fields, but is usually much less abundant in grass. In poor years, it may survive almost entirely in grassland. *M. infantilis* is a small species, whose effects are not as noticeable as its numbers, but in years of abundance, it may thin out grassland vegetation seriously.

THYSANOPTERA. Thrips are equally abundant in grassland and wheatland but, because of the fewer insects in the latter, form a greater proportion of wheat insects. They averaged 174 per 100 sweeps, or 3% of grassland insects and 183 per 100 sweeps, or 21.5% of wheatland insects. Until June 15, few occur, then populations increase until peak abundance is reached about August 8. A rapid increase occurs in wheat at harvest, and a more gradual one in grass. There is strong evidence in the data of migration from prairie into the grain in midsummer as grasses ripen and migration back to the grass when the grain is cut. Species are the same in the two fields. There is some indication of a three-year cycle of abundance, with peaks in 1932, 1935 and 1938. Peaks coincide with years of good rainfall and lows with dry, hot years.

NEUROPTERA. Two families of Neuroptera are a normal but small component of the fauna; Chrysopidae in both fields, Coniopterigidae only in grassland. *Chrysopa oculata* Say equalled about .015% of grassland and .04% of wheat insects. *Malacomyza fitchi* Banks is a minute powdery insect which is predacious on the sedge and other aphids.

HEMIPTERA. True bugs formed 5% of the grassland and 9% of the wheatland insect populations. Miridae were most numerous in species and individuals and Lygaeidae second. Other families were never abundant and, with the exception of Pentatomidae, were represented by a single species in both fields. Several pentatomids were taken occasionally. *Chlamydatus bakeri* Bergr., by far the most abundant mirid, was associated with sage in the prairie and showed a striking three-year cycle of abundance. *Lygus elisus* (VanD.) and *Trigonotylus ruficornis* (Geoff.) occurred on weeds in both fields. *Melanotrichus coagulatus* (Uhl.) was numerous on lamb's-quarters in two years in the wheat field. The lygaeid, *Nysius ericae* (Schill.), a general feeder, was abundant in both fields. Four species of predatory Hemiptera were common: *Triphleps insidiosus* Say, *Nabis ferus* L., *Geocoris bullatus* Say and *Sinea diadema Fab. Piesma cinerea* (Say) is abundant on lamb's-quarters early in the summer in the prairie, migrates into the wheat field completely in midsummer, and returns again to the

prairie at the end of the summer. This is the most striking example of population movements in the study.

HOMOPTERA. The Homoptera are the most abundant order in both fields. It includes 58% of the grassland insects, or twice as many as any other order, and 23% of the wheat insects, twice any other order excepting Thysanoptera. Two families, the Cicadellidae and Aphidae are very numerous, particularly in grassland. The Fulgoridae and Psyllidae have some importance in prairie but little, if any, significance in wheat. Membracidae and Cercopidae are extremely rare in both fields. Coccidae are present only in grassland and are rare in collections.

Cicadellids form 10% of grassland and 19% of wheatland insects. In actual numbers, leafhoppers are four times as numerous in grass as in wheat and reach such enormous proportions as 16,500 per 100 sweeps. A large number of species occurs in both fields but only a few become numerous. The most abundant grassland species was *Deltocephalus auratus* G. and B., followed by *D. collinus* Boh., *D. misellus* Ball and *D. cruciatus* O. and B. The six-spotted leafhopper, *Macrosteles divisus* (Uhl.) is the only species which reaches economic proportions in wheat. It is numerous in wet years and, if grasses dry up early in the prairie, may invade wheat in great numbers in some dry years. In contrast, *D. auratus* thrives best in drier and warmer years, if rainfall has been good the preceeding year.

Aphids constituted almost one-half the grassland population but only about one-thirtieth of that in wheat. The effect of agriculture has thus been a severe reduction of aphid populations. In prairie many species were present, but *Iziphya flabella* (Sanb.) on sedge, exceeded all other insects in numbers. It averaged 2200 per 100 sweeps and reached populations of 19,500 per 100 sweeps. The aphids of wheat are chiefly those associated with weeds. Both aphids and psyllids increased in moist years and both show a tendency toward a three-year cycle of abundance.

COLEOPTERA. The Coleoptera were never numerous in collections from either field and the fewest in numbers of the

major orders. Only .8% of grassland and 2.8% of wheatland insects were beetles. With the exception of the Coccinellidae, nearly all individuals taken were adults. One anthicid, a few chrysomelid and curculionid larvae were the only other immature forms taken. Although this order includes a great many extremely important species (Carabidae, Staphylinidae, Anthicidae and Elateridae) which occur in both fields, these are rarely taken on vegetation because most of them are soil insects. Even the Chrysomelidae are rare. Only two species, both flea beetles, *Phyllotreta pusilla* Horn, chiefly in prairie, and *Psylliodes punctulata* Melsh., chiefly in the wheat field, were numerous enough to be considered important. Coccinellidae and Curculionidae were next most numerous. Cultivation has affected Coleoptera much less than some orders for, although total wheat populations average one-seventh of total grass populations, wheat Coleoptera equal one-half of grass Coleoptera.

LEPIDOPTERA. Lepidoptera were second only to Coleoptera of the major orders in low populations. They constituted only about 1% of the grassland insects and about 5.3% of wheatland insects. There is relatively little difference in actual numbers between prairie and wheat populations but species abundance has been greatly altered. The prairie has a relatively large number of species but the wheat population is composed almost entirely of two species, the pyralid, *Loxostege sticticalis L.* (the beet web-worm) and a gelechiid on pigweed. Some of the most serious pests of crops are Lepidoptera, but as in the case of Coleoptera, the destructive species are chiefly soil-inhabitating. Serious defoliation by lepidopterous larvae was never observed in the grassland, but, in the wheat, pigweeds and Russian thistle were more than once defoliated by caterpillars. The chief families represented in the prairie are: Geometridae, Noctuidae, Gelechiidae, Pyralidae, Tortricidae, Elachistidae, and Eucosmidae.

DIPTERA. Diptera were fifth in abundance of all the orders in grassland but fourth in wheat. Flies constituted 3.8% of grassland and 10.7% of wheatland insects. The average population per 100 sweeps was 209 in grassland and 90

in wheat. Chlorpidae formed almost one-half the flies taken. Chironomidae, Cecidamyiidae, Scatopsidae, Ephydridae and Muscidae were all relatively abundant. Since the collections from vegetation represent adult populations only, the actual populations are considerably greater than this study shows. The Diptera include a number of important species in both fields. *Madiza parva* (Adams), *Meromyza americana* Fitch, *Oscinella incerta* Becker and *Chlorops rubicunda* Adams are abundant in prairie and *Madiza parva* is by far the most important in wheat. The wheat-stem maggot, *Meromyza americana,* though abundant in grassland, is never numerous in wheat in this region. *Chloropisca glabra* Meig., rare in grassland, is occassionaly abundant and of considerable significance in wheat because the larvae are predacious on root aphids. The seed corn maggot, *Hylemyia cilicrura* Rond., occurred in numbers in wheat but seldom causes much damage; it is rare in grassland. Diptera tend to be most numerous in wet years or in the years following wet years.

HYMENOPTERA. Hymenoptera were the fourth most abundant order in grassland but ranked seventh in wheat. Cultivation thus caused a considerable decrease in numbers of Hymenoptera. Average populations per 100 sweeps were 235 in grassland and 29 in wheat. Hymenoptera constituted 4% of grassland and 3.4% of wheat insects. Since most of the Hymenoptera taken were either parasitic or predatory, the order is an important one as a check on other insects. Tenthredinidae were a negligible portion of the prairie fauna and were almost absent in wheat. *Cephus cinctus* (Nort.) is one of the most important and destructive pests of wheat but was taken in only four years in the wheatfield and not at all in the prairie. The Ichneumonoidea are well represented in both fields both in numbers of individuals and species. *Aphidius* and *Lysiphlebus,* parasites of aphids, were particularly abundant in grasland in 1934 and 1938. These were also years of aphid outbreaks. In years when outbreaks of *Loxostege sticticalis* caterpillars occurred, *Bracon vulgaris* Cress., *Pristomerus appalachianus* (Vier.), *Apanteles* sp., *Sagaritis* sp. and others increased notably. Chalcidoidea were the most abun-

dant group and formed three-fifths of the Hymenoptera of both fields. Cynipoidea and Proctotrupoidea were not numerous. Solitary wasps were rare. Ants are represented mainly by *Myrmica scabrinodis* Nyl. Other more numerous ants which no not habitually climb on vegetation were rarely taken. The bees are chiefly Halictidae; they occur in equal numbers in both fields.

Reliability of Population Data

Tests of the reliability of the population data used in this study agree with similar tests by previous investigators. These show that so many collection units are required to secure an estimate of the population which varies less than 10 per cent of the mean that the method becomes impractical if variability of the data must be available for each collection period. The results indicate, however, that 10 or fewer sweeps, but preferably 25 or more, taken as a unit reveal population trends with reasonable accuracy for total populations and abundant species. The reliability of such data may be evaluated by special collections at representative periods of the year. If this procedure is followed, the number of sweeps taken at each collection may be reduced to the minimum for whatever degree of acuracy is required, and each collection handled as one unit. This reduces the work involved sufficiently that the use of sweep-sample data becomes feasible. When the number of sweeps per collection is small the population data for rare species may not be reliable. This is not serious because the ecologist is primarily interested in abundant species. Even five sweeps revealed large population changes at Saskatoon.

Although populations of various species were compared directly in this study, the data may not represent field conditions, because sweeping does not take the same proportion of the population of all species. However, within groups of species of similar habits, e.g. leafhoppers, the relative abundance of various species is shown reasonably well.

Summary and Conclusions

Continuous cropping with wheat favored the economic

species of grasshoppers, wheat stem sawfly, six-spotted leafhopper, all of which feed on wheat; beet webworms, gelechiids, aphids, and *Melanotrichus coagulatus* which feed on pigweeds; *Psylliodes punctulata* and *Hylemyia* spp. on various weeds; and the aphid predator *Chloropisca glabra.* In addition, other weed-infesting insects, *Lygus elisus, Trigonotylus ruficornis, Piesma cinerea, Nysius ericae,* and *Phyllotreta pusilla* were almost equally abundant and common in wheat as in grassland. Thrips, which probably were associated with both grain and grasses, were also equally important in both fields. Most other insects, including those very numerous in grassland were either reduced in abundance or absent in the wheat field. The more important grassland arthropods eliminated or almost so, were: most mites, *Sminthurus* (except in one year), *Melanoplus infantilis, Chlamydatus bakeri, Geocoris discopterus,* all species of *Deltocephalus* except *D. signatifrons* and *D. striatus, Iziphya flabella* and other aphids whose hosts do not occur in the wheat field, *Hyperodes ulkei, Tychius* sp., geometers, elachistids, chloropids other than *Madiza parva* and *Chloropisca, Limosia cilicauda,* tenthredinids, ants, and undoubtedly many parasitic species. The effect on soil insects, the most important ecologically in both fields, is not shown in this study.

Cultural operations, and the absence of a large number of prairie plants in the wheat field have reduced the arthropod population to about one-seventh of that in the grassland. Most of this reduction is attributed to the absence of suitable vegetation for food and shelter for a period of a month or more in spring and fall which forces insects to go elsewhere at these periods. The absence of vegetation in the spring when insects are rapidly increasing in grassland is suggested to be one of the chief reasons for the consistently lower populations in the wheat field. Cutting and removal of the crop at harvest also causes a sudden decline in numbers which is much more marked and earlier than in prairie. Delayed seeding reduced sawfly abundance as compared with early seeding.

Greater than normal precipitation was usually accompanied by a marked increase of the total population. Prolonged drought and above normal temperatures resulted in the low-

est populations recorded. Thrips, aphids, most cicadellids, Diptera and Hymenoptera were favored by better than average moisture conditions. Grasshoppers, a few Hemiptera, Homoptera, Lepidoptera and Diptera were favored by drier than normal weather. A few insects, notably thrips, *Chlamydatus bakeri,* psyllids, some cicadellids and aphids have almost regular cycles of abundance with peaks at three-year intervals. These peaks tend to coincide with years of better than normal moisture conditions. The study was of too short a duration to show any correlation of insect abundance with sun-spot cycles.

Overwintering stages of more than seventy-five species and a table of average and maximum populations per acre and 55 tables of population data were included. Of these, only two are included here. They summarize yearly and seasonal abundance of insect orders in the two fields. The following symbols are used: G = grassland, W = wheatland, L = larvae, N = nymphs, A = adults and T = total of all stages.

Table I. Total Yearly Populations: Insecta

	Field	Stage	Sum of Populations in Twelve Collections										10-year Average
			1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	
Collembola...	G	T	42,760	21,360	7,870	7,320	32,070	42,640	80	25	1,133	19,618	17,487.6
	W	T	20					200			24	22,074	2,231.8
Orthoptera...	G	*N*	*40*	*60*	*70*	*278*	320	*270*	*369*	*300*	*295*	*91*	*209.3*
		A	10		85	160	180	110	175	220	65	25	103.0
	W	*N*	*5*		*25*	*205*	*91*	*70*	*23*	*44*	*97*	*42*	*60.2*
		A	20	50	160	100	345	65	68	240	57	18	112.3
Neuroptera...	G	T	120	80	30		80			30	20	80	44.0
	W	T				10			10	10		15	4.5
Ephemerida..	G	A								10			1.0
	W	A									10		1.0
Plecoptera....	W	A									10		1.0
Odonata.....	W	A		40							15	4	5.9
Corrodentia..	G	A					20	20		20	25	294	37.9
Thysanoptera.	G	T	430	2,660	20	2,204	3,880	470	3,089	4,450	791	2,918	2,091.2
	W	T	535	6,345	1,510	310	8,190	260	184	1,625	2,624	408	2,199.1
Hemiptera....	G	T	1,030	5,425	1,640	4,706	7,925	2,960	1,080	10,244	881	765	3,665.6
	W	T	500	390	185	1,300	520	380	771	572	2,197	2,032	884.7
Homoptera...	G	T	18,080	66,675	9,545	82,656	93,655	11,870	4,676	18,202	48,232	57,015	41,060.6
	W	T	5,265	3,685	80	650	6,917	1,365	2,282	1,935	806	505	2,349.0
Coleoptera....	G	*L*	*120*	*230*	*30*	*144*	*160*	*10*	*32*	*130*	*215*	*94*	*116.5*
		A	490	455	265	602	840	400	244	439	485	309	452.9
	W	*L*		*20*			*5*	*20*					*4.5*
		A	85	360	60	317	201	190	327	269	656	297	276.2
Lepidoptera..	G	*L*	*570*	*940*	*265*	*593*	*1,460*	*555*	*256*	*190*	*232*	*205*	*526.6*
		A	80	80	80	230	440	200	135	90	150	83	156.8
	W	*L*	*170*	*485*	*25*	*1,790*	*160*	*40*	*1,455*	*500*	*109*	*411*	*514.5*
		A		75	10	90	49	10	58	20	5	20	33.7
Diptera.....	G	T	2,610	1,945	2,335	1,907	6,345	2,400	1,084	1,461	2,496	2,453	2,503.6
	W	T	475	585	395	835	2,586	1,210	309	938	1,408	2,089	1,083.0
Hymenoptera.	G	T	2,000	5,130	880	4,890	8,535	1,515	1,169	2,002	1,737	2,286	2,819.4
	W	T	550	300	80	210	350	445	202	617	254	455	346.3

Table II. Average Seasonal Abundance, 1931-1940: Insecta

			Average Population Per 100 Sweeps by Collection Dates										
	Field	Stage	Ap.22	My. 13	June 1	June 17	July 1	July 13	July 25	Aug. 7	Aug. 22	Sep. 4	Sep. 22	Oct. 8
Collembola...	G	T			86.8	1567.0	1611.0	4734.0	3702.0	3646.0	1649.5	477.5	13.8	
	W	T						0.5	32.0	84.5	2124.0	8.4	0.4	
Orthoptera...	G	*N*		*1.0*	*36.1*	*53.5*	*43.5*	*42.0*	*14.0*	*5.0*	*3.0*	*6.5*	*3.8*	*0.9*
		A		2.0		3.5	2.0	22.0	27.5	22.0	11.0	8.5	4.0	0.5
	W	*N*		*0.4*	*9.1*	*15.3*	*17.5*	*12.9*	*1.5*	*2.0*	*1.0*	*0.5*		
		A				1.0	2.5	20.3	30.5	28.0	23.3	5.2	1.5	
Neuroptera...	G	T				9.0	7.0	6.0	3.0	4.0	12.0	3.0		
	W	T						1.0	1.5	1.5	0.5			
Ephmerida...	G	A											1.0	
	W	A									1.0			
Plecoptera....	W	A						1.0						
Odonata.....	W	A						1.5			4.4			
Corrodentia ..	G	T			0.4		3.5		2.0	1.0	15.5	12.0	3.5	
Thysanoptera.	G	T	14.0	8.4	7.6	37.5	35.0	67.0	145.5	882.0	593.0	201.5	75.3	24.4
	W	T				13.2	6.4	245.4	678.0	786.5	430.7	35.3	3.6	
Hemiptera....	G	T	3.0	18.2	472.4	241.0	202.0	416.0	472.5	515.0	455.0	664.0	177.0	29.5
	W	T	1.2		7.8	4.2	28.6	91.1	220.5	137.5	148.3	111.4	117.7	16.4
Homoptera...	G	T	5.0	168.7	3363.6	3403.5	4629.5	6302.0	12305.5	4072.0	3077.5	1547.5	1592.8	593.0
	W	T		0.4	4.2	20.4	246.9	269.2	627.0	601.0	535.4	40.1	3.7	0.7
Coleoptera....	G	*L*	*0.4*		*22.0*	*3.5*	*12.0*	*14.0*	*21.5*	*17.0*	*12.5*	*7.5*	*4.9*	*1.2*
		A	52.5	32.6	35.9	32.0	25.5	76.0	56.5	51.0	45.0	19.0	16.8	10.1
	W	*L*						*2.0*	*2.0*				*0.5*	
		A	8.3	11.3	3.5	5.9	14.2	16.7	41.0	56.0	40.9	49.2	21.8	7.4
Lepidoptera..	G	*L*	*4.4*		*14.0*	*16.0*	*33.0*	*78.0*	*131.5*	*91.0*	*84.5*	*25.0*	*31.6*	*17.6*
		A		0.5	15.3	25.5	12.5	37.0	29.5	12.0	13.5	11.0		
	W	*L*					*33.2*	*103.0*	*182.0*	*23.5*	*96.4*	*75.5*	*0.9*	
		A			1.5	2.0	10.4	7.5	3.5	6.0	2.5	0.5		
Diptera.....	G	T	9.9	128.8	227.4	337.5	473.0	338.0	365.0	279.0	201.0	61.0	47.4	35.6
	W	T	0.5	14.8	22.9	24.9	81.6	286.8	304.5	235.5	71.6	35.3	3.5	1.1
Hymenoptera.	G	T	5.3	42.9	246.6	260.0	320.5	314.0	572.0	406.0	312.0	209.0	110.3	20.8
	W	T		0.5	6.6	9.4	56.0	64.2	67.5	66.0	59.5	13.0	3.6	

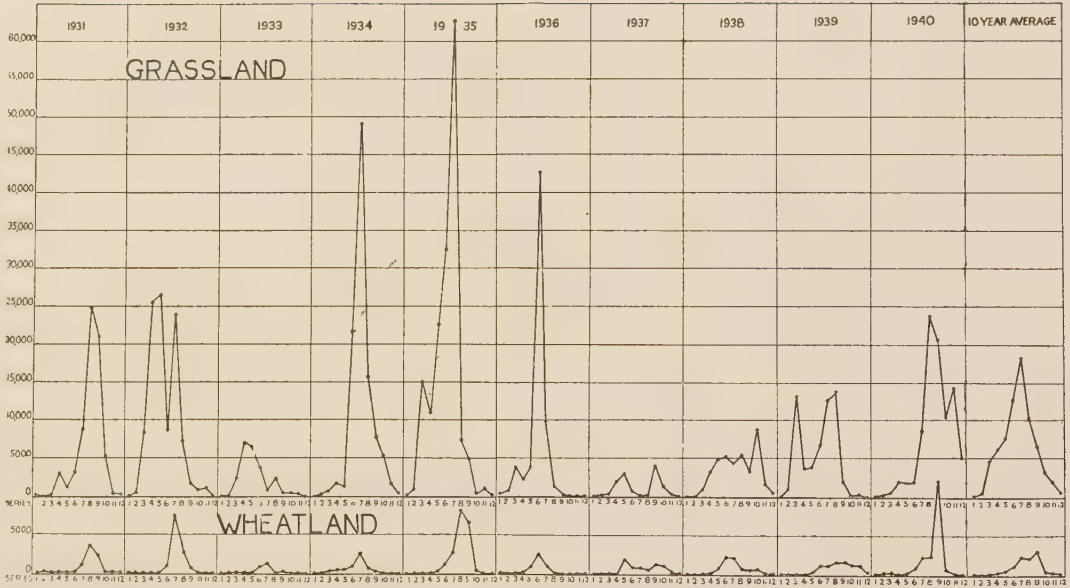

PLATE I. ARTHROPOD POPULATIONS PER 100 SWEEPS

These graphs show a comparison of the total numbers of arthropods collected in the same days in the two fields. The series are the collections made at approximately two week intrvals from April to October over the ten-year period.

VITA

The writer was born at Brown, Manitoba, Canada, on November 29, 1903 of Icelandic parentage. At the age of two, he moved with his parents to a homestead near Mozart, Saskatchewan, where he grew up and later attended the rural school in that vicinity. His high school education was obtained partly at Wynyard, Saskatchewan, and partly at Yorkton, Saskatchewan, with a year and a half intervening between the two during which he taught public school. He attended the University of Saskatchewan at Saskatoon and graduated in 1929. He assisted in the biology laboratory during 1928 and 1929. The writer became associated with the Dominion Entomological Laboratory at Saskatoon in 1927, doing summer work in 1927 and 1928. He became a member of the staff in 1929. With the Dominion Entomological Loboratory he has held in succession the following positions: Insect Pest Investigator, Junior Entomologist, Assistant Entomologist, and his present status, Assistant Agricultural Scientist. The writer married Elizabeth Heiss of Lafayette, Indiana, in 1938 and has one daughter.